# HOW TO USE
# A
# GALVANIC BATTERY IN MEDICINE AND SURGERY

## A Discourse upon Electro-Therapeutics

DELIVERED BEFORE THE HUNTERIAN SOCIETY
UPON NOVEMBER 8TH, 1876

BY

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GREAT ORMOND STREET, ETC. ETC.

LONDON
J. & A. CHURCHILL, NEW BURLINGTON STREET
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# NOTE.

This Address has been published in compliance with the request of several of those who heard it delivered, and who have expressed to me an opinion that busy practitioners may perhaps be glad to have at hand, and in small compass, such information as it contains. It is obviously impossible to do more in the space of an hour than to make a general reference to the therapeutic uses of electricity; and the most that I attempted in this direction was to recal to the recollection of my audience those conditions of disease in which the application of electricity would seem—without doubt—to be required, and to indicate the methods of application most generally useful. The construction of apparatus cannot be understood from verbal or written description alone; and I have appended to the text certain notes, and illustrations of the instruments which I submitted to the Society.

Cavendish Square, W.
*December*, 1876.

# HOW TO USE

# A GALVANIC BATTERY IN MEDICINE AND SURGERY.

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MR. PRESIDENT AND GENTLEMEN,

When your Council did me the honour to ask me to bring before you the subject of Electro-therapeutics, I felt that the invitation was addressed rather to the Hospital to which I am attached than to myself, seeing that to it belongs the merit of having been for some years the pioneer and outpost, so to say, in this metropolis of the scientific and methodical application of electricity to the alleviation and removal of disease; and that we are indebted to one of its distinguished physicians for a remarkable investigation into animal electricity, and the demonstration that much of what we have been accustomed to attribute to a "vital principle" may, in reality, be the effect only of electrical charge and discharge* (a valuable contribution to the correlation of the physical forces);

Preliminary Remarks.

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* See Vital Motion as a Mode of Physical Motion, by C. B. Radcliffe, M.D, &c. Macmillan, 1876.

Preliminary Remarks.

and to my predecessor for the discovery of the special influence of the voltaic current in certain forms of paralysis.*

Addressing an audience the majority of whom are engaged in active practice, and who have seldom much time to devote to the details of medical electricity, it will, I think, be more acceptable for me, instead of discussing the general principles of electricity, or debatable points in electro-physiology and therapeutics, to explain the construction of the instruments which I believe to be the most suitable for medical electrization; to then indicate the usual methods of application, and to conclude by submitting to your consideration a few observations upon electro-therapeutics.

Varieties of Electricity.

We make use of three varieties of electricity in medicine.

Firstly, of static or friction electricity, the electricity of glass and amber, appropriately called from its early investigator, *Franklinism.*

Secondly, of the electricity of chemical action, *Galvanism*, or better, *Voltaism*, the "*Constant Current.*" Unless artificially interrupted, the electricity flows continuously until the battery is exhausted, just as a stream of water flows from an ordinary water pipe; and

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* See Mr. Netten Radcliffe upon the differential reaction of voltaic and induced currents of electricity. Note to page 331, vol. i., of Bazire's translation of Trousseau's Clinical Medicine. Hardwicke, 1867.

Varieties of Electricity.

Thirdly, of *Faradism*, the induced currents of momentary duration which are generated or "*induced*" in a coil of wire by the action upon it under certain circumstances of a magnet or of a voltaic current. There is no steady flow of electricity, but instantaneous currents only. These are repeated many times in a second, and they flow in alternate directions, as in the magneto-electric machine.

It may be well to call to mind for a moment that electricity *per se* is not a panacea, but simply a remedy, most valuable, it is true, but only in appropriate cases and in suitable doses; and that it produces very opposite effects, not only according to its variety, *but according to its method of administration.* The galvanic current applied with intermissions—that is, by moving the conductors during the application—differs altogether in its effects from the very same current applied as a constant current, that is, without intermissions, or with immovable conductors, and Faradism, or the induced current, differs again, *in toto*, from either of these.

Static electricity, though sometimes of the utmost value, has certain inconveniences in its application, and is little used but by specialists.

Electrical Instruments.

In considering electrical instruments, I fear that I must ask your attention at the outset to somewhat dry and uninteresting details, with which I should be loath to trouble you did I not feel con-

Electrical Instruments.

vinced that a clear comprehension of the mechanism of batteries is essential to their pleasant and successful use, and to the easy detection and rectification of faults in their working. Insufficient information upon these points goes far to explain why it is still too common for the medical practitioner (as quoted by Golding Bird nearly thirty years ago) to consider that when his fiat has gone forth "let the patient be electrified," he has done all that is necessary, while the patient usually carries out this mandate by the purchase of a rotary magneto-electric machine, and by using it according to the directions of its maker, who is generally about as well fitted to teach its application in disease as is the maker of an amputating knife to operate with it!

In electrization, a source of electricity is of course necessary, and this is furnished by a cell or cells with contained elements and chemicals. Until quite recently it was impossible to get a *portable* cell that remained always in order and ready for use.* I speak feelingly upon this matter, for from an early period of my electrical experience I have suffered much from batteries—from instruments "striking work" at the most inconvenient moment—from spilling of corrosive acid upon fingers and clothing, to the detriment of both, and of temper too, I fear; but the invention of the "Leclanché" cell has done away with all these petty annoyances, and it is unquestionably the most generally serviceable small-sized element at present to be obtained.

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* Currents of electricity from large fixed batteries are most marked in their curative effects; but patients are not always movable!

The "Leclanché" Cell.

The "Leclanché" cell consists of a zinc plate inserted in powdered sal-ammoniac and a carbon plate inserted in powdered peroxide of manganese in a porous cell; and although it is requisite for this sal-ammoniac to be in a semi-fluid condition, and it will not admit of being left turned quite upside down, it does not suffer from being accidentally overturned, if replaced immediately. Leclanché cells are remarkable for their constancy and persistency in action, and they will remain, with ordinary work, in full efficiency for many months, and can then be readily recharged. They are the only cells that do not require some arrangement by which the elements are either lowered into the exciting fluid, or this is raised to them; and they are necessarily free from the chance of destruction by their elements being inadvertently left in this fluid—a frequent accident with other batteries.

The Tibbits Medical Battery.

Efficient cells are, however, but a first step to the perfection of electrical apparatus, and the mechanism by which the current is brought into use and graduated, and the general accessories of the instrument, are of at least equal importance. The details of construction of the instruments which I am about to describe, and which have been made by Mr. Hawksley, of 300, Oxford Street, have been designed by myself, and it is claimed for them that

The Tibbits Medical Battery.

they place at the service of the busy practitioner a battery that with ordinary care (and no instru-

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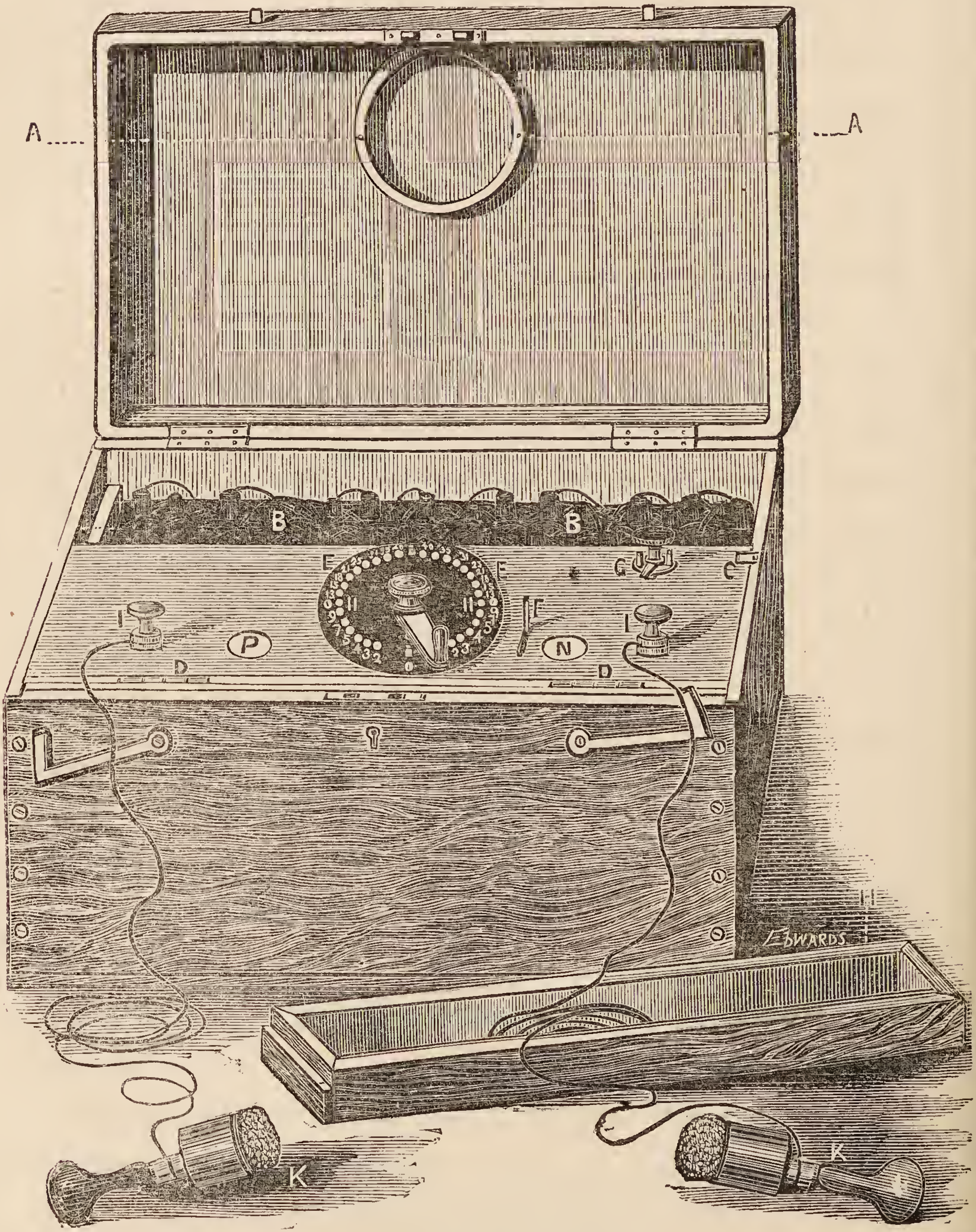
* Fig. 1.



40-Cell Voltaic Battery.

A. Guard preventing the lid being shut, unless the needle of the dial points to "0," and the instrument is out of action.

The Tibbits Medical Battery.

ment will remain in order without this) may be kept upon his consulting-room table, always as available to his service as his stethoscope or ophthalmoscope.

Mr. Hawksley constructs three kinds of batteries:—A Voltaic battery, with any required number of cells, from 15 to 100; a Faradaic battery; and a combined battery, uniting both Voltaic and Faradaic currents.

*The Tibbits Voltaic Battery** has its cells arranged in the interior of a mahogany case, and in use they are hidden from view and from danger, but I now partially expose them by removal of the tray for holding the sponges and accessories. Their connecting wires are brought across the under surface of the element board, which is made to move upon hinges that, when necessary, the cells may be examined, but at other times this element board is held in position by a bolt, and it should never be

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B. Cells shown by the removal of the compartment, H, for sponges and accessories.

C. Bolt to secure the element board, which moves upon the hinges, D.

D, D. Hinges of element board.

E. Dial plate regulating the strength of the current. The needle, when the battery is not in use, should cover the stud, "0," seen to its left.

F. Commutator of the poles. The poles, N and P, are seen through holes cut in the element board.

G. Key by which the current can be shut "off" or "on," without change of position of the conductors. It can also be used by vibrating it backwards and forwards as an "interrupter."

I, I. Binding screws, to which are attached the conducting wires and sponge-holders, &c.

The Tibbits Battery.

needlessly disturbed. These wires conduct the current through the graduating dial, and the position of the needle of this dial determines from how many of the cells the electricity shall be allowed to reach the binding screws, and from them, by way of the conductors, sponge-holders, or electrodes, the body of the patient, or whether it shall be entirely shut off, as is the case when the battery is not in use, and when the needle stands at "0."* When the needle points to any stud numbered on the dial, the number of cells marked on that stud are brought into action, and the needle is made just wide enough to touch one of the studs before it breaks contact with the preceding one, and thus the current may be increased or decreased in power without shock, and while the electrodes are held applied to the patient; but if it were not so made a series of painful shocks would be communicated whenever the current was increased or decreased. Should the needle, from forgetfulness, be left when out of use in any other position than at "0," a

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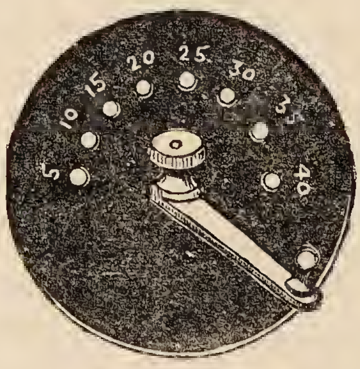
* Fig. 2.



Graduating dial with needle at "0."

The Tibbits Battery.

guard upon the lid of the instrument prevents its being shut, and the operator has his attention called to his inadvertence. A voltaic alternative, or change of direction of the current, is sometimes required in treatment, and the commutator of the poles enables this to be accomplished without alteration in the position of the conductors. By pushing forwards or backwards the handle which moves a lever working below the element board, the current is instantly reversed, and the alternation of the letters "P" and "N" seen through holes cut in the element board indicates at once not only that there has been a change of poles, but which pole is at the moment negative or positive; whereas in all previous instruments, when the poles have been changed, there has either been no letter marking them, or this letter has really been wrong, and one has had to remember this. And under such circumstances, and examining patients in rapid succession, momentary confusion of the poles was very liable to occur, even to a practised operator. A key enables the current to be shut off or on without removal of the conductors. Dirt is a non-conductor of electricity, and the studs of the dial must be kept clean with emery-paper or plate-powder, as also the under surface of the needle, key, and binding screws, which unscrew to admit of removal. In the daily use of a battery the chief work is usually thrown upon the first

The Tibbits Battery.

half (say in a battery of forty cells, upon the first twenty-five), and various arrangements have been added to batteries by ingenious instrument-makers to enable the operator to vary his selection of the cells to be brought into use, and thus to relieve the first half of his battery, or, in other words, to equalize its work. But this unequal work question is more a theoretical than a practical evil; for if the initial cells grow weaker a greater number can be placed in use. I have carefully studied all the proposed modifications, and have found in all of them the remedy worse than the disease, unless the graduating dial be doubled (an original suggestion of my own), so that the initial cells of one week may be made the terminal cells of the next.

Mr. Hawksley constructs batteries, when desired, with this double dial.*

*The Tibbits Induction Battery.*†—The cells of this instrument are similar in construction to those employed in the voltaic battery I have just de-

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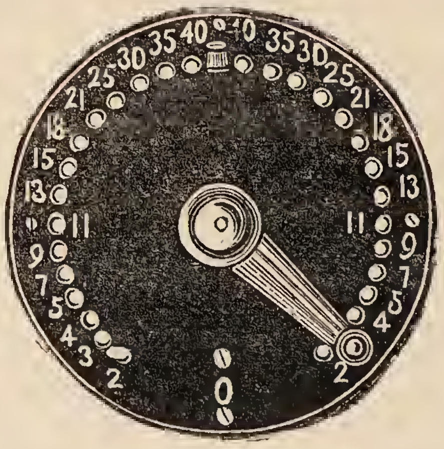
* Fig. 3.



New form of Graduating Dial.

The Tibbits Battery.

scribed, but they are of large size, and the amount of wire in the coils has been experi-

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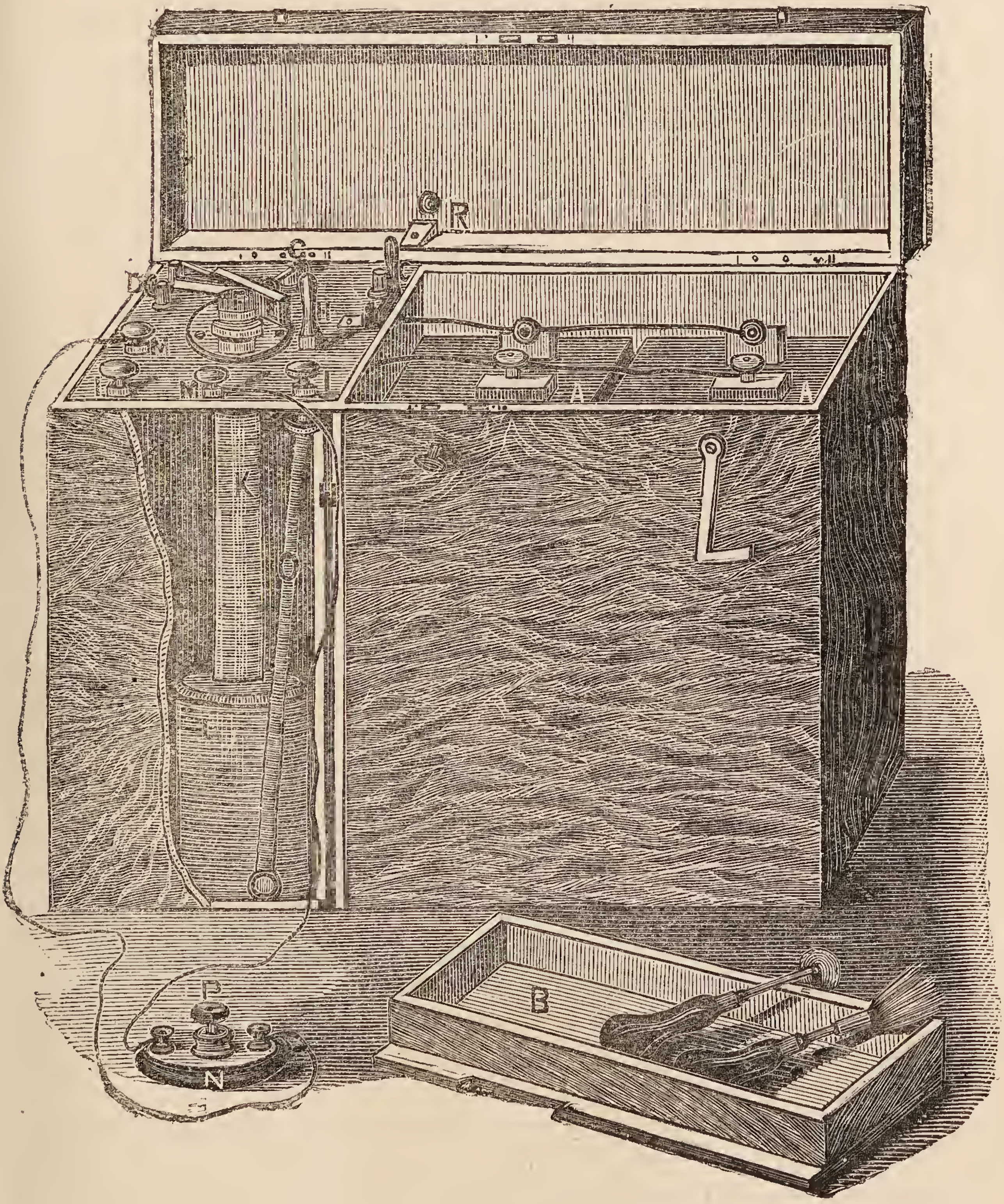
† Fig. 4.



Induction Battery.

A. Cells shown by the removal of the compartment, B, for conductors and accessories.

The Tibbits Battery.

mentally proportioned to their electro-motor power. By the movement of a key the instrument is put into or out of action; and it is so constructed that the shutting of the lid also places it out of action. The primary coil is fixed upon a pedestal, the secondary is movable, and can be lifted over or thrust away from the primary. The degree of action in the secondary coil being proportionate to the extent to which it is brought under the in-

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C. Key by which the instrument is brought into, and put out of, connection with the cells, A, A.

R. Guard which, by shutting the lid, places the instrument out of action, if the operator has inadvertently forgotten to do so.

D. Screw regulating the pressure of a spring which modifies the vibration of the hammer, E.

E. Hammer vibrating between the electro-magnet, F, and the point of a platinized needle regulated by the screw, G.

F. Bundle of iron wires rendered an electro-magnet by the passage of the voltaic current from the cells, A, through the primary coil, K, within which this bundle of wires is inserted.

G. Screw regulating position of a platinized needle.

H. The graduator, a stem to which is attached the movable secondary coil, L. The front part of the case has been cut away in the engraving, to show the construction of the induction apparatus.

I, I. Binding screws for attachment of the conducting wires, &c.

K. The primary coil, fixed upon a pedestal. In the figure, the secondary coil, L, is wholly withdrawn from the action of the primary, and its strength of current depending entirely upon the extent to which it covers the primary, it is evident that the height which the graduator, H, stands above the element board (see page 16, Fig. 6) will exactly indicate this strength.

L. Movable secondary coil.

M, M. Binding screws for attachment of the pedal rheotome, N, for slow interruption. These interruptions are made by the pressure of the operator's foot upon the spring, P, but in practice they are very seldom wanted, and the fittings are only added to the instrument when specially ordered.

O. A spring retaining the secondary coil, L, in any desired position.

The Tibbits Battery.

fluence of the primary, this arrangement admits of the most perfect graduation of the current; and it has been for some time in use in all well-constructed instruments. The innovation I have made consists in limiting the primary coil to its legitimate purpose of induction, and rendering the secondary alone available for application to a patient. I have been long satisfied that therapeutically the distinction between the primary and secondary

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The induced current is obtained as follows:—A wire from the positive pole of the cells, A, A, is connected through the key, C, with the needle at the end of the screw, G. Against the point of this needle the hammer, E, is maintained, when out of use, by the elasticity of the spring, regulated by the screw, D, and which is seen in the figure to press against the shaft of the hammer. A wire from the negative pole of the cells, A, A, is joined to one end of the wire of the primary coil, K, and the other end of this primary coil joins the hammer, E. The current from the cells, A, A, being turned on by the key, C, travels to the needle, G, and as this needle is in metallic contact with the hammer, E, through this hammer and from it through the wire of the primary coil back to the cells, A, A, from which it set out. But this passage of a current through the primary coil causes the bundle of iron wires, F, inserted within it to become magnetic, and consequently to attract the iron hammer, which at once flies to it, the magnetism being stronger than the resistance of its spring. But this movement of the hammer from the point of the needle leaves an open space, *which breaks the circuit as completely as when a telegraph wire is cut.* Magnetism is at once abolished in the bundle of wires, and the hammer returns by the elasticity of its spring, no longer overpowered by magnetism to the point of the needle. *By its return it repairs the break in the current,* and the same process is repeated, the hammer vibrating thus backwards and forwards many times in a second, and each time that it leaves, and each time that it regains the point of the needle, a momentary current is generated in the primary coil, K, and also in the secondary coil, L, if this latter at all overlaps the primary, the power of current in the secondary coil being directly proportional to the degree of this overlapping. We thus see that many "shocks" of induced electricity may be administered, even in one second of time!

The Tibbits Battery.

coil entirely consists in the greater tension of the current of the secondary coil enabling it to penetrate easily several thicknesses of muscle, but there is no therapeutic indication that cannot be fulfilled by the secondary coil; and at its lowest power I have frequently applied it to the conjunctiva. The rapidity of vibration of the interrupting hammer is varied by increasing or decreasing the distance between the point of the needle and the electro-magnet by the protrusion or retraction of the screw, of which the needle forms the end—that is, by increasing or decreasing the space through which the hammer passes in its vibration, and also by altering the pressure of its spring, but there is seldom therapeutic need for change of vibration; and unless this exists it is better *not to alter the adjustment so long as the instrument acts well.** After considerable use the point of the needle, and the exact spot of the platinum disk of the hammer against which this needle impinges, become oxidized, causing weakening or stoppage of the current. This platinum disk has been constructed to rotate,

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* A little care is needed to regulate the vibrating needle. The spring should but *barely touch* the hammer, the adjustment being almost entirely regulated by the protrusion or retraction of the needle by the action of its screw; and the *slightest twist* of this screw will be sufficient. When the vibration is uneven or stops, and careful manipulation of the needle fails to re-establish it, remove the needle and clean its point with emery paper, and if this does not avail, give the disk a *slight* turn with the lever, and bring a new surface of platinum into contact with the needle point.

The Tibbits Battery.

and a hole has been drilled in its circumference.* By inserting a little lever furnished with the instrument into this hole, the slightest twist given to the disk is sufficient to bring a new surface of platinum into contact with the needle point. This will usually be all that is required, but, if not, the needle can be unscrewed, and its point cleaned with emery paper. When in course of time the disk becomes dotted over with spots of oxidation, the screw fixing the hammer in position must be unscrewed, the hammer lifted out, and its surface similarly cleaned.†

*The Tibbits Hospital Combined Battery.*‡—This instrument consists of forty or fifty voltaic cells, and an induction coil and battery, and it is so arranged that the current from either coil or voltaic cells is brought to the same terminals, thus avoiding the trouble of constantly changing the conductors, a point of the greatest possible convenience when examining patients for diagnostic purposes by both forms of electricity, either in succession or alternately. In it there are combined in one case the essential parts of my voltaic

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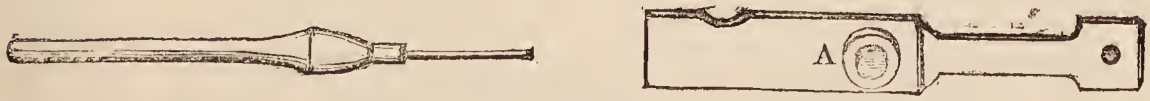
[*] Fig. 5.



The Platinum Disk and Lever.

[†] These directions (probably given for the first time in such minute detail) apply to every induction battery yet made; and by following them, the necessity of sending the battery to the instrument maker may be often avoided.

The Tibbits Battery.

and induction batteries. The dial differs from that already described only in being furnished with an additional stud, lettered "*Coil.*" When the

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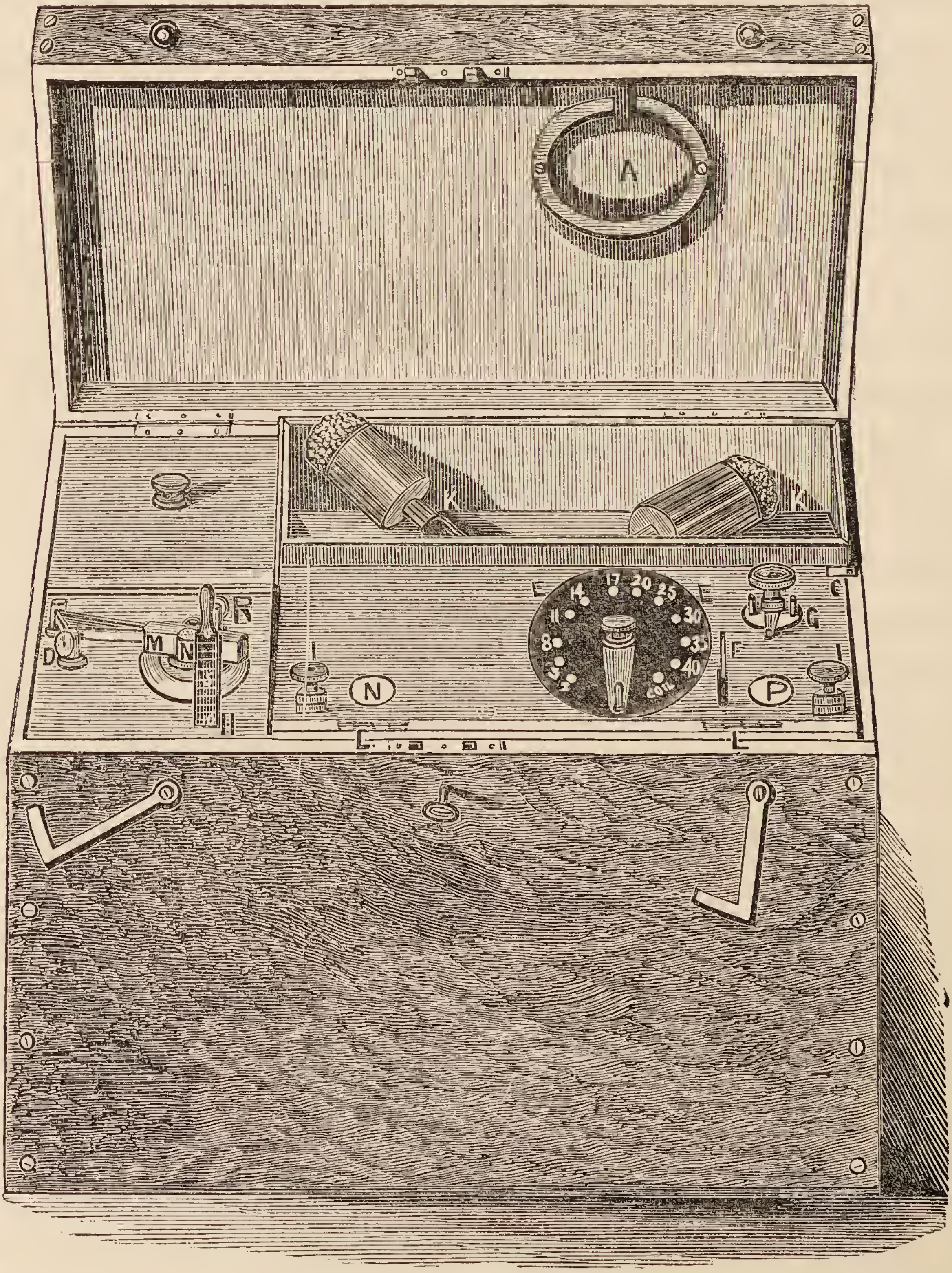
‡ Fig. 6.



Hospital Combined Battery.

A. Guard block.
K. Tray for holding accessories.
C. Bolt securing element board.
G. Key for interruping current.

The Tibbits Battery.

needle points to this stud the current from the Faradaic coil is brought into action; when it points to the numbered studs, the cells numbered thereon as in my voltaic instrument, and when it points to "0," both currents are shut off. In the more common form of this instrument, its various parts are arranged in a square mahogany case, the voltaic cells being all on the same level; and this, as most simple in construction, is to be recommended where patients are usually brought to the operator for treatment. But a more portable arrangement, especially convenient for use when visiting patients at their own homes, is constructed by packing the cells in tiers, thus uniting the maximum of power with the minimum of space.*

Other instruments, such as those of Stöhrer and Weiss, are excellent, and were unsurpassed until the invention and improvement of the Leclanché cell. But I might talk upon instruments for hours without exhausting the list; and I have felt obliged to limit myself to a description of those I believe best fitted to our requirements; but it of course must be understood that *my further observations will apply equally to currents of electricity*

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E. Dial plate.
F. Commutator of the poles.
I, I. Binding screws for conducting wires.
L, L. Hinges of element board.
H. Graduator of coil.
M. Hammer.
N. Electro-magnet.
R. Screw regulating position of needle.
D. Screw regulating spring of hammer.

*furnished by any properly constructed and reliable apparatus.*

The Application of Electricity.

*The Application of Electricity.*—I shall use the term "electrization" in all remarks applicable equally to Voltaism and Faradism.

Electrization may be applied generally and

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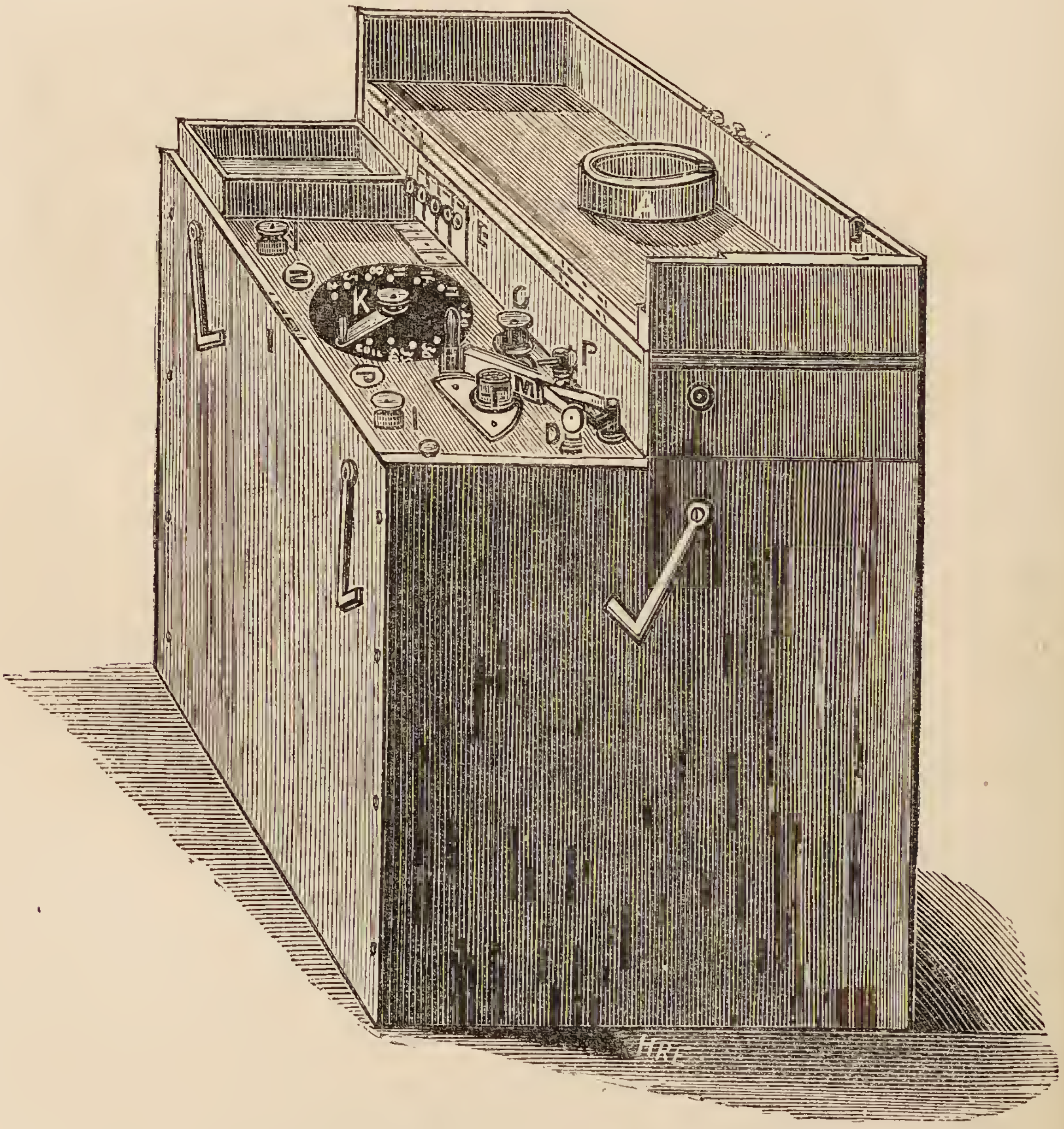
* Fig. 7.



The Tibbits Portable Combined Battery.

In Fig. 7 the instrument is seen with the lid open, ready for use.

A. Guard.
D. Spring of hammer.
E. Connecting screws.
F. Electro-magnet.
G. Interrupter.
H. Graduator of coil.
I, I. Terminals.
K. Regulating dial.
M. Vibrating hammer.
P. Screw regulating needle.

The Application of Electricity.

locally—it may be arrested in the skin without stimulating the subjacent organs; or, on the contrary, it may be caused to penetrate the skin and made to concentrate its power on deeply-seated muscles or nerves. The skin itself is a non-con-

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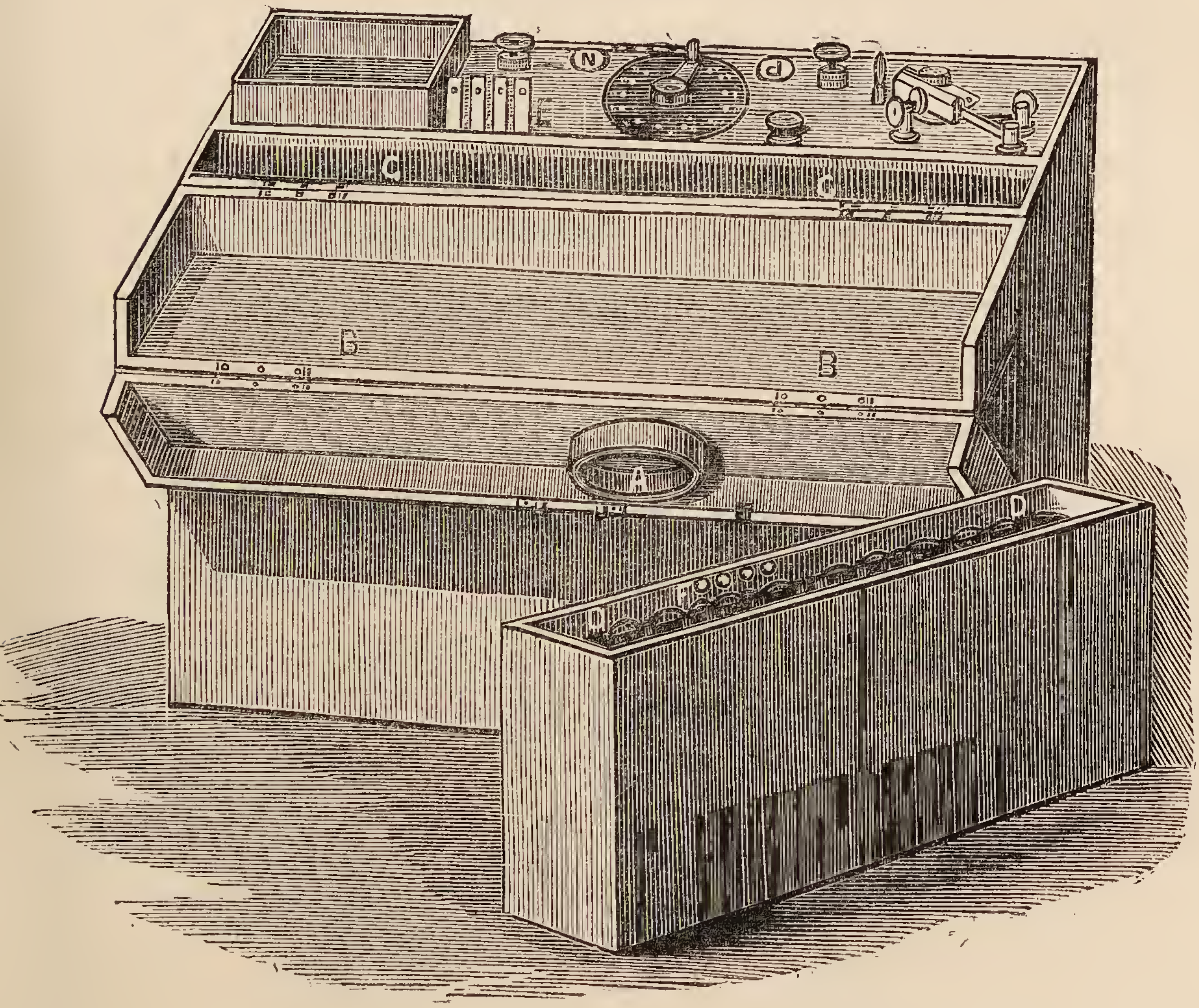
* Fig. 8.



The Tibbits Portable Combined Battery.

Fig. 8 shows the packing of the cells in tiers, the lid, which folds upon itself by a second pair of hinges, B, B, having been thrown back to expose the tray, D, which, with its contained cells, has been lifted out from the space, G, G. This tray is held in position, and connection with its cells made by four brass screws, inserted through four springs, E, the screwholes, F, being also seen in the tray, D. These screws, which have been removed in Fig. 8, are seen *in situ* in E, Fig. 7. The other details are similar to those of the Hospital Battery, Fig. 6.

The Application of Electricity.

ductor of electricity, and if it be carefully dried and powdered with some absorbent powder, the dry metallic conductors of an electrical instrument, in moderate action, applied to it will produce only sparks and crackling, but no physiological phenomena. *The electricity does not penetrate the skin.* If the dry conductors are replaced by well moistened sponges there will be produced neither sparks nor crackling, but very variable phenomena of contractility or sensibility, according as the electricity acts upon a muscle, a nerve, or an osseous surface;[*] and this brings us to the consideration of conductors.

Different kinds of Rheophores.

*Conductors, Sponge-holders, Electrodes, Rheophores.*[†][‡]

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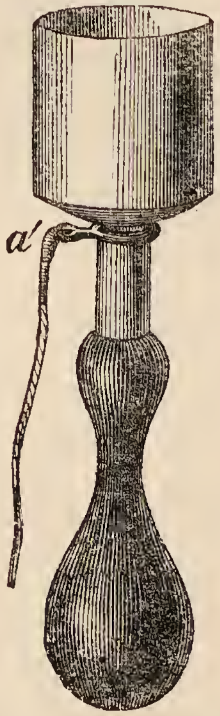
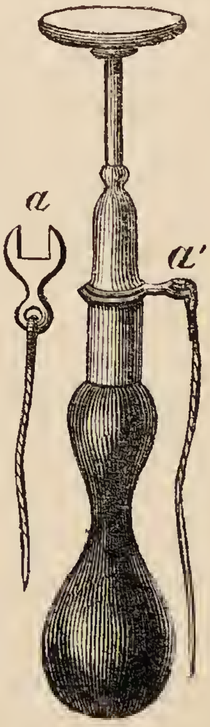
[*] See Duchenne (de Boulogne) On Localized Electrization and its Applications to Pathology and Therapeutics (English Edition). Part I., pp. 38—40. London: Churchill.

[†] FIG. 9.



Cylindrical Sponge-holder.

[‡] FIG. 10.



Metallic Disk, covered with Wash-leather.

Different kinds of Rheophores.

—The varieties of conductors are infinite. The most essential are well moistened sponges contained in cylinders; metallic disks covered with wet wash-leather; the same metallic disks polished and not covered with leather, and a brush of metallic wire;* all having conveniently shaped handles and, of course, some form of conducting cord or wire between these conductors and the poles of the instrument. I have had endless trouble with conducting cords, which are always liable to get out of order and cause interruption in the current; and I strongly advise that nothing should be used but very thin copper wire, coated with gutta-percha in the same way as that known as "telegraph wire." This is perfectly insulated, sufficiently pliable for all practical purposes, it is inexpensive, it does not kink, it will fit any sort of rheophore, and if the end breaks, all that is necessary is to scrape off with a pocket-knife the coating for about a couple of inches from the broken end. For use where the rheophores remain immovable during the whole time of application, the ordinary telegraph wire is more convenient, and from its much greater diameter will wear much longer, but it is not sufficiently flexible for other

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* The wire brush is shown contained in the tray B, for accessories in Fig. 4, page 11. In Fig. 9 is also shown the usual method of connecting the conducting cord with the rheophore, which is seen *in situ* received into the screw socket of the rheophore in $a'$. The cord is very apt to get frayed where it passes through the eyelet hole, and that the wire I recommend is not open to this objection is not the least of its advantages.

Different kinds of Rheophores.

purposes. Most sponge-holders are made much too long in the cylinder, the proper dimensions for general use being about $1\frac{1}{2} \times 1\frac{1}{8}$ inches, and the sponge should be large enough to fit the cylinder tightly, or it will be apt to slip out, and when not in use it should be taken out of the holder and kept in water until required again. Conductors with fixed sponges, although convenient, soon become fouled, and interrupt the current unless the sponges are frequently renewed. The disk rheophore covered with wash-leather is very generally useful, and by using the edge it may be made to answer in the majority of cases for a pointed conductor. It has also an advantage over the sponge of allowing firm pressure to be made without the inconvenience of water being squeezed out.*

The conductors I have just described and a wire brush, comprise those supplied with my instruments.

The Constant Current.

*Methods of applying Electricity.*—The voltaic

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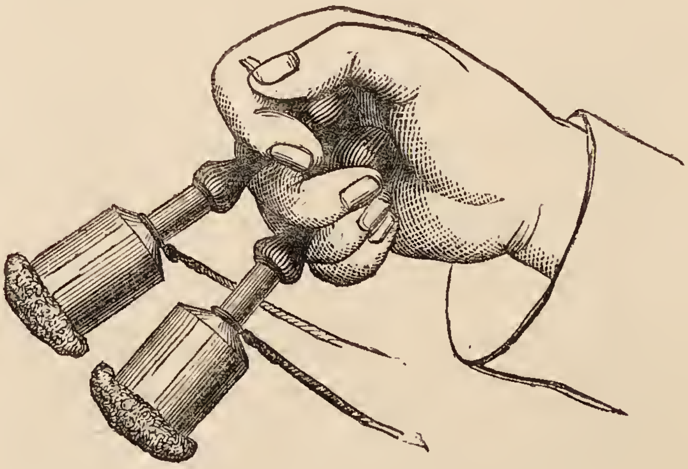
* Fig. 11.



Sponge-holders with Sponges inserted.

The Constant Current.

current is applied as a "constant" and as an "interrupted voltaic" current. In the "constant" voltaic current, the conductors are maintained immovable upon the skin; or the feet or hands, as the case may be, are immersed in tepid water with which the conducting wires of the battery are in contact, and the current is allowed to pass during the time required. The tension of voltaic electricity is so low that salt is needed to render the water a good conductor. In the "interrupted voltaic current," the current is interrupted by gliding over the skin one or both of the rheophores, or keeping one rheophore stationary and lifting and reapplying the second at intervals of about one to two seconds.

Radcliffe's Positive Charge.

*Radcliffe's Positive Charge.*—This is an application of *positive* voltaic electricity originated by Dr. Radcliffe. The patient and the battery must both be insulated, the passage of the current must be constant, and a wire, termed a "ground wire," must be carried from the negative pole of the battery or from the negative rheophore to the earth —that is, there must be two wires from the negative pole, one to be applied as well as the positive to the patient, and the other taken "to earth." This latter may conveniently be attached to a metallic chandelier, or gas pipe, which always gives direct metallic conduction to the ground. With careful insulation the negative electricity passes away by this wire, and while the current

Radcliffe's Positive Charge.

circulates the patient continues "charged" with positive electricity. A sheet of gutta-percha, about four feet square by half an inch thick, will answer admirably to insulate the patient, and the accessories. It is often convenient in making this application, to insert the hand or foot of the patient, as the case may be, in a vessel containing tepid salt and water, in which is immersed the wire from one pole, while the sponge from the other pole is held applied to some part of the body, the operator taking care not to touch the patient, or the insulation would be destroyed; but to hold the sponge-holder by its insulating handle only; or a second limb is immersed with the wire from the second pole in another vessel of salt and water. Administered thus, this is especially an "electric bath" of positive electricity.

Direct Muscular Electrization.

*Direct Muscular Electrization,* termed by the German school "intra-muscular," consists, as the name implies, in electrizing a muscle by placing the rheophores on the muscle itself; and is accomplished by placing well-moistened rheophores on points of the skin corresponding to the muscle it is desired to act upon. The rheophores must always be applied over the fleshy body of the muscle, and not over its tendons; and they should be applied in succession to all points of its surface, and the thicker the substance of the muscle the more intense must be the current, because a weak current

Direct Muscular Electrization.

will only produce excitation of the superficial layers. Using Faradism, it is a good rule to promenade, as it were, the two rheophores, held in the same hand,* in lines along and across the muscle, or group of muscles; keeping them stationary on *every point of the muscle* for about thirty seconds, and letting the entire application vary from five to fifteen minutes, according to therapeutic requirements. Using interrupted voltaism, it is better to maintain the positive rheophore stationary, and to "paint," as it were, the entire muscle with the negative glided in lines from the positive. With constant voltaism both rheophores must be held immovable.

Indirect Muscular Electrization.

*Indirect Muscular Electrization*, termed by the German school "extra-muscular," consists in causing muscular contraction by acting upon the special nerve trunk and branches, instead of by placing the rheophores upon the muscle itself. When it is desired to act exclusively upon the nerve, it is convenient to place a broad conductor, such as a sponge contained in a cylinder, upon some little sensitive part of the body—such as the sternum—and to apply a fine-pointed conductor to the most superficial point of the nerve it is desired to act upon; but in practice it is often better to place the larger conductor upon the muscle itself.

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* See Fig. 11, page 22.

Electrization of Central Organs of Nervous System.

Electrization of Spinal Cord.

*Electrization of Central Organs of Nervous System.*—The voltaic current is the only form of electricity which exerts any special action on the central nervous system. To affect the brain, well-moistened sponges may be applied to each mastoid process, to each temple, or to the frontal and occipital protuberances. The sponges must be held immovable. To galvanize the superior cervical ganglion of the sympathetic, one electrode of small size must be deeply pressed into the auriculo-maxillary fossa, and the other with a good-sized sponge applied over the sixth or seventh cervical vertebra, or to the manubrium sterni, close to the border of the sterno-mastoid. The spinal cord may be electrized by keeping one sponge, usually the positive, stationary, and moving the other up and down by the sides of the vertebræ, or one pole may be applied to the spine, and the other held to a nerve or muscle.

Cutaneous Electrization.

*Cutaneous Faradization.*—When it is desired to act only upon the skin, faradization is invariably made use of. The solid metallic disks (Fig. 10, page 20), but polished and without leather, may be applied by their metallic surfaces to the skin, and either kept stationary or moved over it with greater or less rapidity, in proportion to the degree of irritation it is required to produce; or the wire-brush (Fig. 4, page 11) may be substituted for one of the disks, and moved over the skin, the other disk being held stationary. The skin should be carefully dried and sprinkled with some absorbent powder, such as starch or violet powder.

Electrization of Internal Organs.

*Electrization of Internal Organs.*—The rectum and muscles of the anus may be electrized by introducing into the rectum the rectal rheophore, a metallic stem insulated by gum elastic, and moving it over the internal surface, bringing it also into contact with the levator and sphincter ani. A well moistened sponge connected with the other pole may be applied to the abdominal muscles or to the neighbourhood of the anus. The rectum must be first freed from fæcal matter. The bladder is most readily electrized by the introduction into the rectum of the rectal rheophore, and into the bladder—previously emptied—of a curved metallic sound insulated by an elastic catheter to within an inch of its vesical extremity. This sound must be brought into contact successively with all points of the neck of the bladder. The uterus by the introduction of the rectal rheophore, connected with one pole, to the os uteri, and by the application of two sponges from the other pole, one to the abdominal parietes, the other to the lumbar region. The larynx, externally by one sponge to the nape of the neck, and the second to the exterior of the larynx; or, internally, a sponge to the neck as before, and the introduction by the aid of the laryngoscope of a small bit of sponge at the end of a curved metallic stem, insulated by a gum elastic catheter, the current not being allowed to pass until it is seen by the laryngeal mirror that the sponge is in the desired position. The male genital organs by moist rheophores to the scrotum over the testicle.

Electrization of the Organs of the Senses.

*Electrization of the Organs of the Senses.*—The retina may be electrized by a moistened conductor to the closed eye, and the second to the temple or to the mastoid process of the same side. The auditory nerve by one conductor tipped with sponge, and inserted to the bottom of the meatus, the second being held in the hand of the opposite side; or the meatus may be filled with tepid water, and a metallic wire traversing the axis of a vulcanite tube may be immersed in the water, the second conductor being a well moistened sponge to the nape of the neck. The olfactory nerve by sponge to neck, and movement over all points of the nasal mucous membrane of a metallic sound, insulated except at its extremity. The nerves of taste by sponge to the neck, and movement of the second conductor over the base and borders of the tongue.

Electro-Diagnosis.

*In Diagnosis* electricity will assist us only in those conditions in which there is altered muscular contractility, or cutaneous or muscular sensibility, or both. Healthy nerves and muscles respond to the electric stimulus whatever variety of electricity is employed; but in disease this reaction may be increased or diminished, or altogether absent. The irritability of a muscle is tested by ascertaining

Test of Electro-Contractility.

the lowest power which will cause its contraction. Supposing the case to be one of hemiplegia, say of the left side, having found the lowest power causing contraction of any one of the healthy muscles of the right side, we apply that same power to *identical points* of the corresponding muscle of the diseased side, and note whether there is contraction. If there is, we decrease the power of the current, and if contraction still occurs there is increased irritability, and *vice versâ.* It is essential that on both sides there should be exact similarity in the application; and this is especially important with the voltaic current, for healthy muscles and nerves answer more readily to it when it flows down the limb—*i.e.*, with positive pole above and negative below—than when it flows up, and consequently a reversal of the poles will influence the result. In testing a case of paraplegia where there is equal disease on both sides, we must be guided by a knowledge of the strength of current usually required to bring about contraction.

Precautions in mode of Application.

In a case of hemiplegia it will be found almost invariably that irritability to both varieties of electricity is normal in the muscles. This proves the integrity of the muscular tissue—if the muscle also responds to indirect excitation by its motor nerve, we know, in addition, that the conducting power of the nerve is uninjured, and that the spinal cord has preserved its integrity at the spot where the nerve is given off. The disease is in the brain. If we find irritability diminished—more than that slight diminution from disuse which is restored by two or three faradizations—there is disease of cord, or nerve, or muscular tissue, and the disease, as a rule, will be in direct proportion to the amount of diminished irritability. The reaction to the interrupted voltaic current will generally correspond to that to faradism; but in some cases in which response to faradism is abolished, the reaction to a slowly interrupted voltaic current is not only preserved, but greatly increased. In these cases the nerve will react to neither current; and the increased irritability is due to the muscular tissue, *without the agency of nerve*, and it exists only in peripheral and never in central lesion. By this differential reaction we may diagnose peripheral from central paralysis. For example, paralysis of the facial nerve from facial hemiplegia, paralysis of the extensors of the wrist and fingers, due to lead poisoning from commencing muscular atrophy, or from rheumatic paralysis, progressive muscular atrophy from paralysis from section of a nerve, essential infantile paralysis from other varieties of paralysis—all important questions as affecting treatment.

Irritability diminished.

Diagnosis of Peripheral from Central Disease.

In paralysis from disease of the cord there is almost invariably diminution of reaction in the affected muscles to all varieties of electricity, and

Decreased Irritability.

the posession of normal irritability will often help us in the diagnosis of cases of emotional paraplegia. The condition of muscular irritability will largely aid us to distinguish between real and pretended disease; and finally, its entire abolition in all the muscles of the body, is conclusive proof of death.

Increased Irritability.

Increased irritability points to increased vascularity, irritative lesion of brain or cord, or both, but in such cases we seldom require the aid of electricity to complete our diagnosis.

Electro-Therapeutics.

*Electro-therapeutics.*—I propose to refer very briefly to the general principles regulating the application of electricity in medicine, and to instance a few of the special forms of disease in which its administration would seem to be imperatively demanded.

Effects upon Nutrition.

The influence of faradism in those cases in which it does not produce muscular contraction, is chiefly stimulant; where it does produce contraction it acts in addition as an artificial gymnast, imitating natural muscular action in a way quite impossible to any agency but electricity. It is in cases where there is muscular response to it, but not to the will, that faradism is often of immense service, and it can then be replaced by no other remedy known to medicine. In these cases, too, its dosage is important, that the weakened muscles may not be exhausted. The "interrupted voltaic current" is similar in its action upon muscle to faradism,

Importance of Dosage of Electricity.

Effects of the Constant Current.

Importance of Care in Administration.

but this is complicated by chemical and electrolytic effects upon the animal tissues, and by certain special influences upon the central nervous system. It is of great value in the treatment of those cases of loss of power in which the paralysed muscles, whose response to faradism is wholly lost, contract under the influence of a slowly interrupted voltaic current. The Constant Voltaic Current, the "*Constant Current*" of which we have all heard so much, differs *toto cælo* from the above, for it consists not of *any* voltaic current from *any* voltaic battery, but of a current from that form of battery which supplies one, *not only continuous, but one which does not vary appreciably in power during the application; and not only so, but of this current so applied to the patient by the operator, that its flow through that part of the patient's body to which it is directed shall be as continuous as the stream of the current from the battery to the conductors. Unless thus applied, it is not a constant current, and its therapeutic application will be unsatisfactory.* The effects of the constant current thus applied are chiefly sedative, restorative, or refreshing, and absorbent or resolvent. It has great power in relieving pain, and it is sometimes unapproached in this power by any other remedy. None of its therapeutic results is more firmly established; and were it in no other respect of use, its services here would entitle it to the foremost

Relief of Pain.

Neuralgia.

rank as a remedy. It is of the greatest benefit in neuralgia. The sponges should be so applied as to include the affected nerve in their circuit; the number of cells should be the highest number that the patient can bear without pain, and care should be taken not only to maintain the conductors quite immovable upon the body, but to avoid shock by abruptly shutting the electricity off or on; two cells should be commenced with, and the current so gradually increased, that no shock is felt, and at the end of the application it must be as gradually decreased, for it must be remembered that an abrupt removal of the sponges would give a shock. The length of application from five to ten minutes, and the frequency usually once or twice daily; but I have met with the best results in obstinate cases by applying the current as frequently as the paroxysms of pain recurred. This treatment was directed to be carried out in the case of a patient under the care of Dr. Radcliffe, in the National Hospital, who for two years had been subject to attacks of neuralgic pain, occurring from six to twenty times daily. She was galvanized twenty-seven times upon the first day. There was rapid improvement; the attacks, after a month's treatment, were reduced to one or two weekly, and in three months she was discharged cured. Dr. Althaus considers that the positive pole should always be applied to the seat of pain; and although

Relief of Pain. I agree with the witty observation of Dr. Poore, that " there is no connection between '*anode*' and '*anodyne*,' " the negative pole is more irritating than the positive, and on this account the latter is better borne. It is, however, the constancy of the application that is of primary importance. I generally place the negative pole with a large sponge upon the spine over the origin of the nerve affected, and apply the positive pole to the painful spot; and if there are more spots than one, to them all in succession. It is seldom that relief is not afforded, even if cure do not result. The number of cells must be determined according to the region affected. In the face, about five to ten will generally be sufficient; and the application must be discontinued upon the occurrence of the slightest giddiness. Galvanization of the cerebral hemispheres is very beneficial in true migraine (sick headache), two to three cells to each temple, or to each mastoid process. In angina pectoris, one pole to spine, and the other to the region of the heart. Dr. Anstie and Dr. Russell Reynolds both quote successful cases; and I have had many which I believe to have been as fairly cured as an ague fit may be said to be cured by quinine. The pains of muscular rheumatism may almost invariably be removed or mitigated by cutaneous faradization, and so rapidly, as in many cases to appear marvellous. The current should be strictly limited to the skin. The voltaic current has been found of the greatest

Rheumatic Gout.

use by Althaus in rheumatic gout. He directs the positive pole to the cervical spine, and the negative to the pit of the stomach, the sponges being of large size, and a mild current allowed to flow for from three to five minutes. This frequently causes sleep. Pain may be relieved by a small conductor from the positive pole to the painful spot, the negative with a large sponge being held in the neighbourhood. Length of application, one to five minutes. Dr. Poore has recorded a very successful result from the use of localized galvanization. The disease had existed for three months, but the severity of the pain had much diminished, excepting towards evening, when exacerbations occurred. The wrist was considerably swollen, and absolutely stiff, the hand pronated and could not be supinated, and the hand and fingers were immensely swollen, so as completely to obscure their anatomy, while the fingers were extended, stiff, pale, and cold, and the nutrition of the entire limb impaired. The whole limb, and especially the hand, was thoroughly sponged with the negative pole, the positive being held in the patient's other hand. After the third application the swelling rapidly subsided, and in about a fortnight the hand, although still stiff, had resumed its natural aspect. The muscles were then faradized and shampooed.*

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* A Text-Book of Electricity, by G. V. Poore, M.D., &c. Macmillan and Co. 1876. Page 145.

Cerebral Paralysis.

It is probable that in some cases of cerebral paralysis, where the clot or softening is of limited extent, the process of reparation in the brain may be promoted by the use of the constant current; *but too much caution cannot be exercised in its application.* Peripheral faradization is seldom advisable until some three or four months after the attack. Faradization should then be used of a strength just sufficient to bring the muscles into full contraction. In those cases in which the paralysed muscles are cold, blue, flaccid, and ill-nourished, and where a generally anæmic type predominates, the muscles should be well sponged with the voltaic current (the positive pole being held stationary upon the origin of the muscle, and the negative being evenly "painted" as it were over its entire surface), alternately with faradization. Applications to be made daily, or every other day, for from five minutes to fifteen minutes. "Radcliffe's Positive Charge" will often help these cases greatly; and I have seen some more improved by it than by any other method of electrization.

Spinal Paralysis.

In the use of electricity in spinal paralysis, we must be guided by a consideration of the nature of the disease, and the condition of the cord, muscles, and nerves. The evidence of the good resulting from central electrization of the cord is much greater than can be adduced in support of similar treatment of the brain. Such applications, when powerless to cure, not unfrequently relieve some of the most distressing symptoms.

Diseases of Cord.

Peripheral faradization must not be employed during the early period of active mischief in the cord; but in the persisting localized paralysis following upon myelitis it is often of the greatest service, especially in relieving symptoms of paralysis of the bladder and rectum.

The dribbling of urine, which is so troublesome in some paraplegic cases, may be frequently relieved, and the condition of the sufferer made much more tolerable. The interrupted voltaic current should always be given a trial where faradization fails—one pole to the lumbar spine, and the other to the pubes; length of application about five minutes; interruptions three or four times a minute. Application, twice daily.

In traumatic paralysis, in local palsies, such as mercurial and lead palsy, in all peripheral palsies, and notably in facial paralysis, in rheumatic and in all forms of atrophic paralysis, and in some varieties of ocular paralysis, some one or other of the different forms of electricity will be essential to the most successful treatment. Central applications of the voltaic current must be made according to therapeutic requirements, and the methods already described; but the general rule applicable to all localized muscular electrization, is to test the

Central Application of Voltaic Current.

muscles with the faradaic and the interrupted voltaic current, and to electrize them with that current to which they most readily respond.

Locomotor Ataxy.

In locomotor ataxy, the constant current applied to the spine has, in one case under my care, resulted in perfect recovery, and in many others it has relieved many of the symptoms. In the case referred to, the ataxy had existed for eighteen months, the gait being most characteristic, and the patient unable to walk without assistance. There was also considerable anæsthesia. The current from fifteen to twenty cells was applied to the spine by large sponges (the sponge-holders being five inches in diameter), the positive sponge to the nape of the neck, and the negative sponge to the lower lumbar vertebræ, both sponges held immovable, for ten minutes upon going to bed and getting up in the morning, followed by five minutes' faradization to the legs and feet with the wire brush. The patient had improved in one month, could walk without assistance in three, and was apparently quite well in eight.

Spasmodic Diseases.

In spasmodic diseases, electricity should always be given a trial. In writer's cramp, which consists essentially of a paroxysm of spasm whenever the sufferer is called upon to execute some special movement, but in which there is no true paralysis, Dr. Poore has very successfully applied the refreshing and restorative effects of the voltaic current, by localizing it in the nerves of the affected muscles, and exercising these muscles *during the passage of the current*, by various gymnastic movements. I have been successful in two cases by faradization of the antagonists of the suffering muscles, united with the localization in the muscles themselves of "Radcliffe's Positive Charge" for fifteen minutes daily; and similar treatment was most beneficial in a case of torticollis in a young lady twenty years of age. In her case, the spasm was almost constant, had existed for twelve months, and had resisted every kind of treatment, including hypodermic injections of morphia, and the wearing of a mechanical apparatus. There was some wasting of the sterno-mastoid and trapezius on the right side, and the corresponding muscles of the left side exhibited increased irritability to all forms of electricity, and were the seat of pain and well-nigh constant clonic spasm. The voltaic current from fifteen cells was localized in these muscles, by stationary sponges, for fifteen minutes night and morning, and at the same time the antagonist muscles were well faradized. In a week there was slight improvement, and the patient was then directed to sit in front of a looking-glass, and try to bring the head into the normal position in time with the counting "one," "two," of a bystander. After a month's treatment, improvement was more rapid, but it was six months before recovery was complete.

Spasmodic Diseases.

Torticollis.

Infantile Paralysis.

I propose to consider, finally, and somewhat more fully, the application of electricity in "*essential infantile paralysis;*" for the more my experience of this disease extends, the more strongly do I feel how lamentable it is that the physiological treatment of the affected muscles in this affection has not yet become the routine treatment invariably directed by the practitioner in attendance, and that within a week of the outset of the disease. Were it so, an incalculable amount of helplessness, and subsequent unhappiness, would be spared to children. Children, as we know, between the ages of three months and four to five years, are liable to suffer from attacks of paralysis, differing in many respects from the paralysis of adult life. In infantile paralysis premonitory symptoms are often absent or but slight, and not seldom the child is put to bed well, and found in the morning to have lost the use of one or more of its limbs; but the visceral muscles are never affected, and the paralysis is motor only, sensation being unaltered. The paralysed muscles soon suffer in their nutrition, the limb affected is found to be much colder than its fellow; and tested by electricity there is complete abolition of farado-contractility, but marked increase to the interrupted voltaic current. The muscles begin to atrophy, tend to subsequent degeneration or absolute destruction of tissue, and the final result is often their entire disappearance, the skin literally

Infantile Paralysis.

adhering to the bones, accompanied by deformity or club foot, from adapted atrophy of the opponents of the paralysed muscles, but never by rigidity. If proper treatment is adopted *in time*, and before muscular degeneration and atrophy have advanced too far, the greater number of cases of infantile paralysis admit of cure; and where perfect recovery cannot be obtained, we have the great authority of Mr. Adams for the statement that deformity ought never to result.* For the first week or ten days after the attack, or for as long as may be necessary, the case must be treated upon general principles, but localized treatment should be had recourse to as soon as possible, and *before the muscles themselves begin to atrophy, or to be impaired in their nutrition.* The reaction to electricity of the weakened muscles should be tested, and each muscle should be daily electrized for a few minutes with that current to which it responds, and of a strength just sufficient to produce muscular contraction. There is no ground for the feeling of natural repugnance that exists against galvanizing children of such tender years, for if the precaution is taken of commencing with only moistened sponges (no current being allowed to pass), and then gradually inuring them to the strange sensation, they betray as a rule but slight signs of pain,

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* Club Foot: its Causes, Pathology, and Treatment. By W. Adams, F.R.C.S., &c. 2nd Edition. Churchill, 1873. Page 79 et seq.

Infantile Paralysis.

and I have even seen the operation amuse them. In addition to electrization, the paralysed limbs should be immersed in water, as hot as can be borne, for a quarter of an hour twice a day, and should afterwards be well rubbed and shampooed; or they may be sponged in very hot water and then shampooed. It is of the greatest importance that in the intervals of treatment the temperature of the affected muscles should be maintained at as high a degree as possible; and if the leg is affected, a stocking of pure silk should be constantly worn, day and night, in addition to the ordinary clothing; if the arm, a silken sleeve. At the Children's Hospital I invariably directed the parents to make these of ordinary chamois leather, as a cheap substitute for silk, one for day and one for night wear. When *any* amount of voluntary power has been restored by electricity, it is most important that the child should be encouraged to use the limb, and practise various movements. Passive movements are of equal importance; and the mother or nurse must be taught to frequently exercise the paralysed muscles to the fullest extent of their normal movements—*e.g.*, if the extensors of the hand and fingers are paralysed, the hand and fingers should be flexed and extended completely by the nurse at intervals of a few seconds, for some minutes, and so on with all the paralysed muscles in succession. If the above directions are

Infantile Paralysis.

patiently and faithfully carried out, there are very few cases indeed, if there be any, in which we need fear deformity, and this never until the child begins to walk. If, however, we then observe distortion commencing, the weakened muscles will require mechanical support; but great care must be taken that this support *is in nowise allowed to supersede the healthy exercise of the muscles.*

Many cases in which deformity has already taken place will yet amend, and this without the necessity for tenotomy; but, of course, where the muscles are greatly contracted, they will require division; but even with these latter patients the treatment directed must be assiduously carried out as soon as admissible after the operation. Mr. Adams details a most instructive case* of a boy, eight years of age, who was placed under his care suffering from club foot, and in whom the deformity had been removed by operation three times previously, at intervals of two years. In Mr. Adams's opinion, the relapse had been the result principally of the omission of the physiological means of treatment, which had not been directed to be employed. Under proper treatment, the form of the foot was restored, and the muscular power of the limb rapidly improved.

Essential infantile paralysis is always a tedious

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* Adams: loc. cit., p. 293.

Infantile Paralysis.

disease, and it is unfortunate that it is generally, when all kinds of treatment have been vainly exhausted, that electricity is appealed to as a forlorn hope. In these chronic cases, a satisfactory result can only be expected after long perseverance; but there appears to be scarcely any limit to the time in which even complete recovery is possible, provided that the paralysed muscles retain their electro-contractility, and so show that they have not degenerated; but I am able to adduce an instance of what electricity will sometimes accomplish in an apparently hopeless case, and which was regarded as such by myself:—

A child was brought to me in 1869, suffering from a typical attack of infantile paralysis affecting the muscles of the left thigh and leg. Electrical treatment was recommended, but circumstances only allowed of its administration upon three or four occasions, and the child went to India, returning in June, 1875 (after an interval of six years), with a useless leg, measuring some inches less in circumference than the healthy limb, and with a certain amount of deformity. There was complete abolition of reaction to both currents in all the affected muscles, and I was consequently unable to hold out hope of any benefit; but at the earnest request of the mother I instructed her how to apply electricity, recommending that she should apply it twice daily, in addition to shampooing.

Infantile Paralysis.

This treatment has been now carried out almost daily, for sixteen months, with a result that is surprising. There is now little difference in the appearance of the two limbs, there is reaction in all the muscles but the anterior tibial muscles, and a large amount of voluntary power has returned. The child has been under the joint care of Mr. Adams and myself, and Mr. Adams has succeeded, by mechanical and gymnastic treatment, in curing the deformity. This case forces upon our attention the question, how far it is advisable for the medical practitioner who prescribes electricity to sanction its administration by the patients themselves. While there is no doubt that the most explicit directions will often be misunderstood, or fail in being correctly carried out, yet it would be practically impossible (to say nothing of the expense to the patient) for any medical man to himself apply the electricity daily for fifteen months ; and we are compelled, in certain cases, to do our best in instructing *some one attendant of the patient* how to carry out the treatment, making her do this a few times in our presence, *and looking sharply after her afterwards*, and in addition explaining everything as fully as possible to her mistress. Moreover, we must not lose sight of the fact that, with electricity as with other remedies, the skill of the physician is shown in determining how, when, and in what dose to administer it, and his judgment in selecting those cases in which its administration may be wisely committed to others.

Electricity in Surgery.

*Surgery*, Gentlemen, no less than medicine, owes much to electricity, for in addition to its indebtedness for the galvanic cautery, the dispersion of tumours by the electrolytic or chemical action of electricity, is making daily progress, and will probably before very long become a recognised part of ordinary therapeutics. The galvanic cautery is an application of the power possessed by the voltaic current of raising a conducting wire to a red or white heat. For this purpose ordinary medical batteries are altogether useless, special batteries possessing elements of large surface being required. Speaking as a Physician, I do not for a moment presume to address you upon galvano-caustic operations in surgery, but my investigations into the best method of constructing medical batteries have almost of necessity drawn my attention to those employed in surgery, and to what I believe to be their faults of construction; and I have endeavoured to remedy these, and to design for the surgeon a more manageable and convenient battery than any other with which I am acquainted.

The Tibbits Galvano-Caustic Battery.

*The Tibbits Galvano-Caustic Battery** consists of elements of zinc and platinum projecting into two vulcanite cells, which are so arranged that they can be moved vertically up and down, and fixed in

The Tibbits Galvano-Caustic Battery.

any position by a revolving screw. The exciting fluid fills only the lower third of these cells, and

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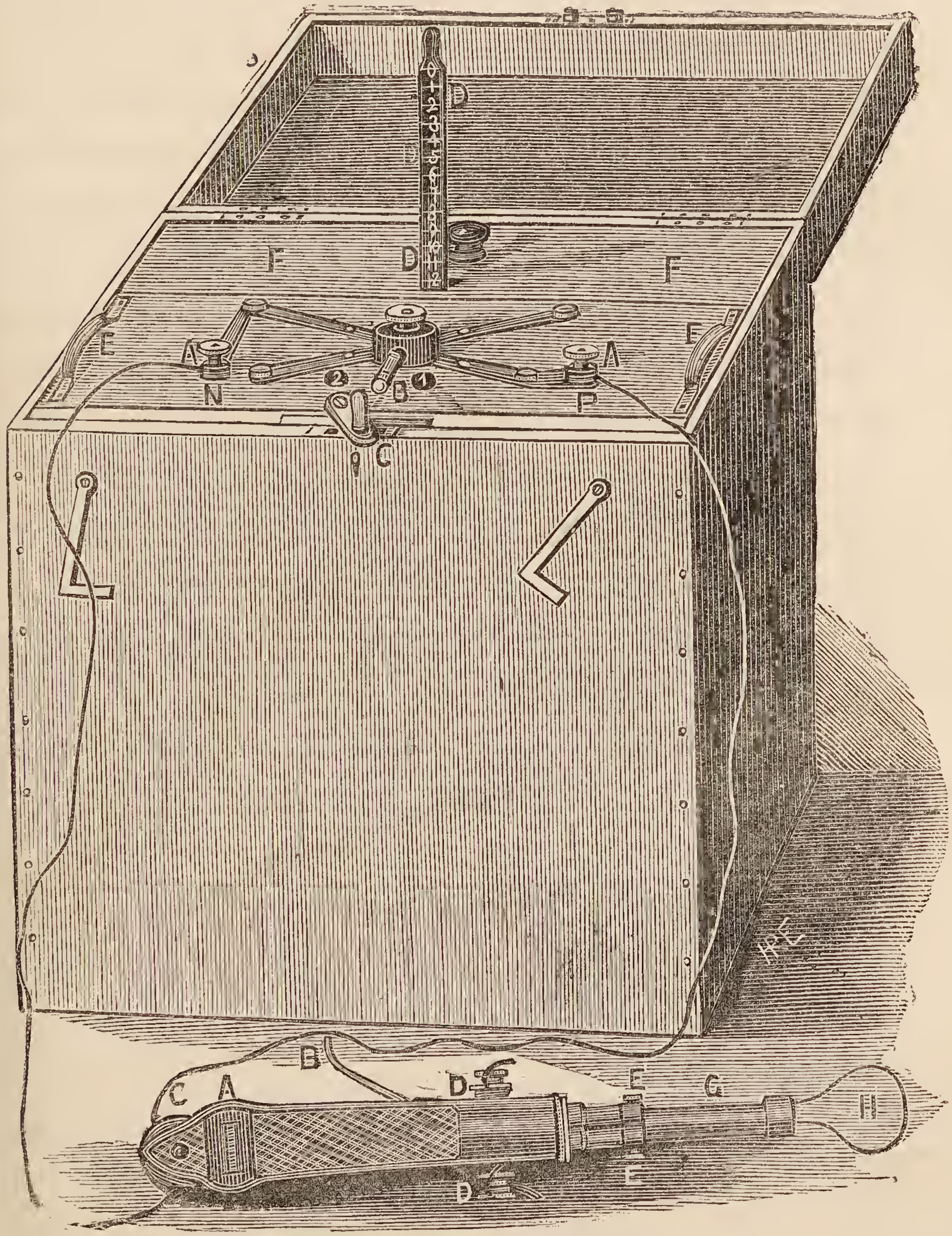
* Fig. 12.



Hospital Galvano-Caustic Battery.

A, A. Binding screws for attachment of conducting wires.
B. Lever for varying the area of the elements.

The Tibbits Galvano-Caustic Battery.

the power of the current depends directly upon the degree of immersion of the elements in this fluid; that is, upon the height to which the cells are raised by the screw. An index stem, divided into twelve degrees, rises above the element board as the cells are lifted, and enables the operator to read off in a moment the exact degree of immersion of the elements—in other words, *the exact heating power*—while the elements themselves are so connected that they may be employed either as one large or two small cells, and this by the mere turning to the right or left of the handle of a lever. For all large and important operations fresh fluid should be used, but this will not be necessary in minor ones; and a cover has been fitted to the cells to enable the instrument to be carried about without danger of the fluid spilling. This is, I believe, the first galvano-caustic battery admitting of exact graduation of the power of the current of electricity.

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C. Revolving screw for lifting the cells.

D. Graduator, which in the figure has risen to "12," the battery being in full action. When the battery is out of use, the graduator stands at "0," on a level with the element board, E.

E, E. Handles for lifting out the element board and elements. If it is necessary to carry the instrument any considerable distance while charged with fluid, the slab, F, is lifted off and replaced by the element board and elements. Vulcanite stoppers (not shown in the figure) are then fitted to the cells, and the slab, F, placed over them, filling the position occupied in the figure by the element board, E. The conducting wires are seen in the figure to be attached to an *Ecraseur*. The battery is constructed in two sizes, as a "Hospital" and as a "Portable" battery.

Electrolysis.

In *Electrolysis* medical batteries are used, and it is chiefly applicable to tumours or growths which from their nature or situation are difficult or impossible to be removed by the knife. One or more needles connected with a voltaic battery in action are inserted into the tumour, and it is subjected to the disintegrating influence of the current of electricity. There is no hæmorrhage, and after the dispersion of small tumours there is frequently no visible scar. The number of needles must of course vary with the size of the tumour; for a very small one one needle is sufficient, but for a growth of say an inch in breadth, two or three will be required; and in subcutaneous tumours, where it is desired to avoid injury to the skin, the needles should be insulated by gum elastic, or vulcanite, to within a quarter of an inch of their points. Local anæsthesia of some kind will usually be required; and it may often be sufficiently produced by painting the part with a mixture of one part of carbolic acid to two parts of sulphuric ether. The pain and the *fear* of the operation will thus be reduced to a minimum. A current of moderate tension from about eight to twenty cells of my battery, should be allowed to pass for from five to thirty minutes. Where only one needle is used, it is generally better to connect it with the negative pole, a large sponge from the positive pole being applied in the neighbourhood of the tumour. Where more needles than one are

Electrolysis.

inserted, they should be connected with both poles. These are the most generally useful needles,* and I have had made for them holders with eyelet holes for the attachment of conducting wires which render the operator independent of special conducting cords, for with a coil of insulated wire and a pocket knife he can fit up his needles in a few minutes in any way best adapted to his proposed operation.

Electro-puncture in Aneurisms.

Electrolysis has been successfully employed in several cases of aneurism. Where pressure and ligature admit of application, it is hardly necessary to say that the preference should be given to them; but many internal aneurisms, and especially aortic aneurisms, cannot be thus treated, and in such cases the question of electro-puncture should be carefully considered, and, when called for, it should

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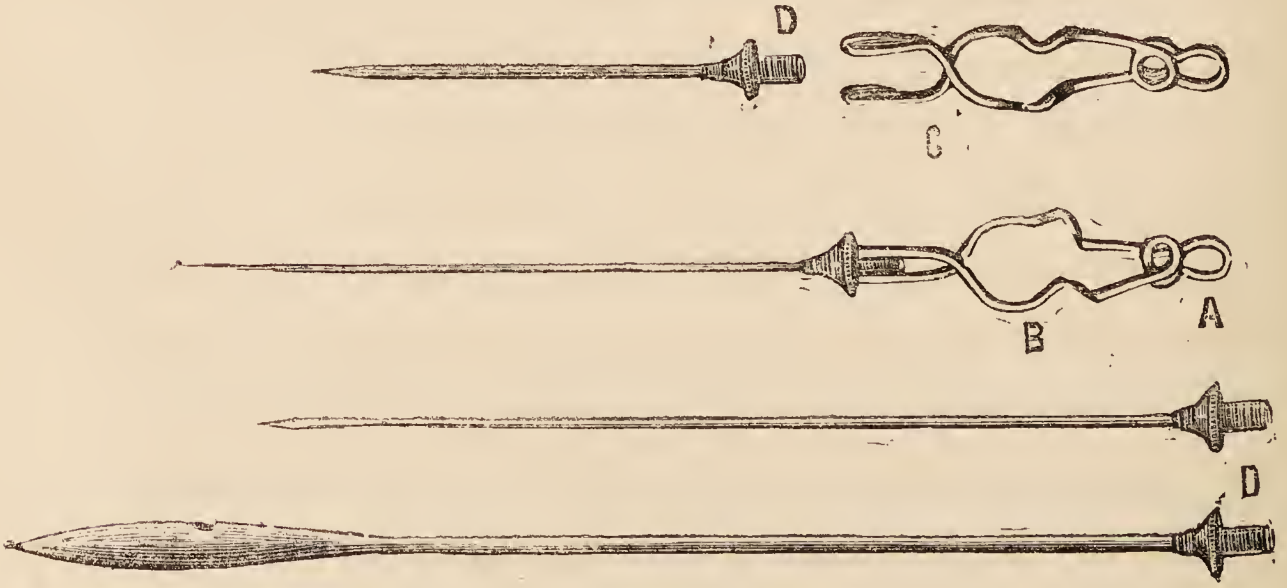
* Fig. 13.



Electrolysis Needles and Needle Holders. By pressing the spring side B, the holder opens as shown in C, to grasp the needle D. The wire is twisted into the eyelet hole A.

Electro-puncture in Aneurisms.

not be too long delayed. Two fine, sharp, and carefully insulated needles, one connected with each pole, should be introduced into the aneurismal sac, and the current allowed to pass for from half an hour to an hour, the needles carefully withdrawn, and their punctures covered with a bit of lint soaked in collodion or styptic colloid. Authorities are divided as to the kinds of aneurism calculated for electro-puncture, but there is no doubt that an aneurism pressing on the parietes, but not having actually perforated them, is the best adapted for this treatment, and that it is contra-indicated where the sac is of large size, or where large trunks issue from it.

Electrolysis in Malignant Disease.

The treatment of malignant tumours by electrolysis is yet *sub judice*, but the evidence in its favour has recently much accumulated, and its full and exhaustive trial by competent observers possessing the opportunities of large hospital practice ought not to be much longer delayed. Neftel of New York, who is its chief advocate, contends that malignant tumours are at first entirely local, and he explains their recurrence, after removal by the knife, from the fact of the impossibility of the whole of the diseased mass being excised, as apparently healthy parts when microscopically examined show that they have already become infected. Electrolysis he considers acts not only on the tumour but also on the surrounding tissues,

Electrolysis of Malignant Tumours.

Electrolysis of Malignant Tumours.

the current being diffused to some distance in all directions. After electrolysis he applies a mild and not painful current for from a quarter to half an hour daily to the *locus morbi*, and continues this for some months. In one of his cases, a mammary tumour existed of the size of a small orange. Three needles, from the negative pole of thirty-five cells, were inserted for half an hour under chloroform, and the operation was repeated thrice at intervals of a week, daily external galvanization being also used. The tumour gradually became smaller, and at last disappeared, but external treatment was continued for several months. At the end of a year there had been no relapse. In another case, in which the tumour had been excised by Marion Sims, it reappeared, and was again removed by the same surgeon, and pronounced cancerous. It again reappeared, and was then electrolyzed, upon three occasions, by two, three, and four needles respectively, and with a current gradually increased from ten to thirty cells. The tumour by degrees grew less, and in three months was entirely dispersed; while, when the patient died from another disease three years afterwards, there had been no recurrence.

If future experience should demonstrate that localization of the galvanic current exerts a more powerful destroying or retarding influence upon disease germs than local treatment by caustics, a much more hopeful future will be afforded to sufferers from malignant disease.

Concluding Remarks.

In conclusion, Gentlemen, allow me to thank you for the attention with which you have listened to this imperfect discourse. The time allotted to it has not permitted me to do justice to its subject; but I trust that I have succeeded in indicating the importance of electricity as one of our most powerful and serviceable remedies—as a supplement to, not as a substitute for, the more ordinary resources of therapeutics. A theoretical belief in its efficacy is widespread in our profession; its common adoption as a weapon to be not seldom used in our daily battle with disease, is yet in the future—may I hope a not distant future—and that a knowledge of medical electricity may soon be considered an indispensable part of the education of every medical practitioner!

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